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# STRAWBERRY CULTURE

WESTERN UNITED STATES



Farmers' Bulletin No. 1027  
U. S. DEPARTMENT OF AGRICULTURE

STRAWBERRIES can be grown in those parts of the western United States in which ordinary farm crops are irrigated as well as in western Oregon and Washington, where irrigation is not essential but may be profitable. The principles of irrigating strawberries are essentially the same as those for other crops. Because strawberries are sensitive to the alkali salts that irrigation brings to the surface, such salts must be washed out or skimmed off.

The strawberry grower, after choosing a suitable site and preparing the soil carefully, should select varieties adapted to his district and needs. He should use plants that are disease-free. In California, southern Arizona, New Mexico, and Texas the plants should have undergone a rest period. Usually the growers plant during the period of greatest rainfall. By using the recommended systems of training and care before, during, and after setting of the plants and the suggested methods of decreasing diseases and insect pests, he should obtain better yields. A grower can furnish consumers a better product by using good methods of harvesting and shipment. He can prolong the fresh-fruit season only a little by the use of cold storage, but he can extend his market by growing varieties suitable for preserving, canning, and freezing.

# STRAWBERRY CULTURE: WESTERN UNITED STATES

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## REGION TO WHICH THIS BULLETIN APPLIES

**STRAWBERRIES** can be grown in the United States west of the one-hundredth meridian (fig. 1) if suitable practices are followed. In most of the region they must be grown largely under irrigation to make production sure. In the region there is, however, one important area—the western part of Oregon and Washington—where rainfall is sufficient for strawberries to grow without irrigation.

Along the Pacific coast, and to a slight extent elsewhere in this region, strawberries are grown for the general markets of the Western and Middle Western States and even for eastern markets. The largest centers of commercial strawberry production for the fresh-fruit market in the part of the country here considered are in Los Angeles and Orange Counties in southern California; in the Santa Clara Valley, south of San Francisco; and in the lower Yakima River Valley, Wash. A considerable number of carloads are produced in other sections. The Willamette Valley of Oregon and the Puget Sound section of Washington are very important commercial centers, the crop from these sections being used largely by the frozen-pack industry.

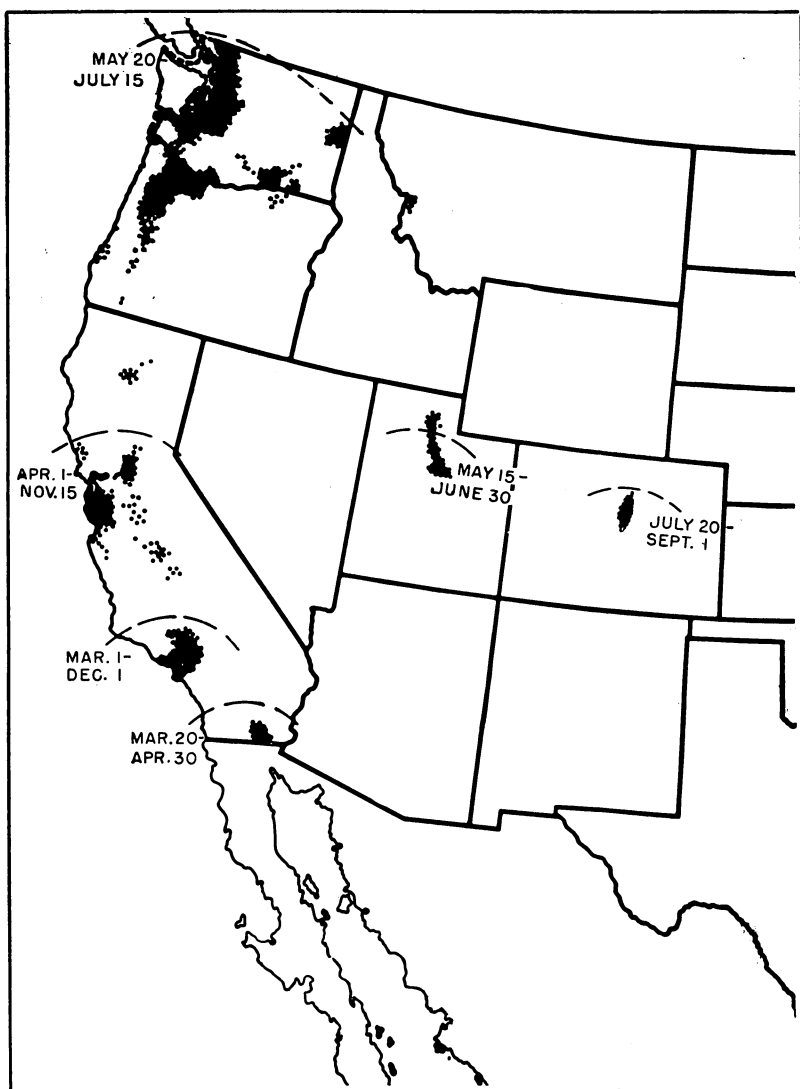


Figure 1.—Outline map of the part of the United States west of the one-hundredth meridian showing areas in which strawberries are grown largely under irrigation, as well as an area in western Oregon and Washington where irrigation is not necessary. Dates indicate approximate shipping seasons.

The practices followed in growing strawberries in the semiarid parts of the West are quite different from those in the Eastern States.<sup>1</sup>

### LOCATING A STRAWBERRY PLANTATION

In locating a strawberry plantation in the Western States the grower must consider such factors as moisture and alkalinity, as well as accessibility to markets, transportation facilities, and labor supply.

<sup>1</sup> See Farmers' Bulletins 1026, Strawberry Culture: South Atlantic and Gulf Coast Regions; 1028, Strawberry Culture: Eastern United States; and 1043, Strawberry Varieties in the United States.

The moisture supply, either throughout the entire year or for certain long periods, is less than that needed for the production of strawberries. Because of this, except in western Oregon and Washington and in the extreme northwestern part of California, strawberries can be grown commercially only where water for irrigation can be supplied when it is needed.

Much of the soil in this region contains alkali, and irrigation brings alkaline salts to the surface in such quantities that the strawberry plants are injured or even killed outright. Usually the first indication of alkali injury is burning, mottling, or yellowing of the leaves in the lower spots in the field, but plants may be killed outright without yellowing or mottling. Flooding is generally used to wash the alkali out of the soil. Sometimes it may even pay to skim off the upper inch or two of soil where the alkali has come to the surface. In selecting a site for a strawberry field, places where the soils are known to contain alkali should be avoided.

It is obvious that a community provided with good railroad service, refrigerator cars, and icing stations is in a very much better position to deliver strawberries in good condition to distant markets than one located only a comparatively short distance from a large center of population but without readily available means of transportation.

If strawberries are grown near large towns and cities the local demands may be largely depended on to absorb the supply of fruit. The improved highways in many States and the use of trucks have materially increased the distances over which fruit may be transported by private conveyances to local markets. On the other hand, many locations admirably adapted to strawberry growing so far as natural advantages are concerned are quite impossible from a commercial standpoint because they lack the necessary means of transportation by which the fruit can be delivered to the markets in good condition.

The accessibility of supplies, such as berry boxes and crates, is closely related to the available transportation service. In this respect, as well as with regard to the advantages of shipping in carloads, a location for commercial growing in which there are large strawberry interests is usually much to be preferred to one without such community interests.

The prospective strawberry grower must take into account very fully the means of getting his fruit to the consumer if he is to avoid failure even after his crop has been produced successfully.

The care of a strawberry plantation in irrigated areas ordinarily takes the time of one man for each acre up to the picking season, and under intensive cultivation in nonirrigated areas one man for each 4 or 5 acres. During the harvest season additional help is necessary. The amount of such help varies with the size of the crop, but usually 6 to 10 pickers per acre are needed. In some localities growers have found difficulty in procuring labor to pick their crops and have had severe losses on this account. Therefore, before the production of strawberries is begun on a large scale, an adequate supply of labor from year to year should be assured.

## PREPARING THE SOIL

The preparation of land for planting strawberries should be complete and thorough. Any neglect or failure in this operation before the plants are set is likely to prove costly later. If the soil is not abundantly supplied with humus, it should be supplied before the plants are set. Humus can be added either by adequate applications of manure or by growing and turning under one or more green-manure crops, preferably a legume, such as clover, cowpea, or some other crop adapted to the district.

### TWO-YEAR PREPARATION

It may be necessary to begin preparing the soil one or two seasons before the plants are set. The best preparation for a successful strawberry plantation is the application of barnyard manure. This, however, is becoming difficult to obtain. Cover crops, particularly legumes, may be grown for a year or two before the strawberries are planted. Some growers use vetch with oats or barley, planting them in the fall or early spring and allowing the crop to ripen, then disking it down, and allowing the reseeded crop to grow during the following winter. Such a cropping system greatly increases the productivity of the soil. In some fields it is necessary to apply commercial fertilizers to increase the growth of the cover crop.

Because of the danger that strawberries will be attacked by a disease that affects tomatoes and potatoes and by aphids (plant lice) that attack roots of corn, strawberries usually should not follow such crops. Grain crops, alfalfa, sweetpotatoes, and some of the green-manure crops are considered better to precede strawberries. If alfalfa is used, it may be best to follow it with some grain or cultivated crop for at least a part of a season until the alfalfa roots are decomposed. Where white grubs are troublesome, strawberries should follow a legume that white grubs avoid.

### PREPARATION FOR IRRIGATION

Land that is to be irrigated must be leveled or contoured, and furrows should be made to carry the water through the field. Unless the field is level or the slope even, water will collect in depressions, some plants will be flooded, and others will not receive enough water. By plowing, grading, and harrowing, the field can be put in condition to be easily irrigated and thoroughly drained. The tilth should be similar to that of a vegetable garden. In most districts the ditches for distributing the irrigation water are very shallow (fig. 2, *A* and *B*). If shallow furrows are used, preparation of the land should include the grading and leveling needed to provide for ease in irrigation when the furrows are made.

In most districts strawberries are set on the level, without furrows, to be grown in hills or on raised beds made after the runner plants begin to root (figs. 2, *B*, and 3, *B*). The practice in other districts is to make furrows and raised beds before the plants are set (fig. 3, *A*). Plants are grown in hills (figs. 2, *C*, and 3, *C*) in most of the districts in which they are set on the level, and when they need irrigation shallow furrows are made between the rows.

The width of raised beds, whether made after or before the setting of the plants, ranges from slightly more than a foot to several feet.



Figure 2.—*A*, Field of strawberries with plants set on the level with the furrows and relatively wide beds following the contour of the land, Watsonville, Calif. *B*, Field with plants set on the level 6 inches apart in two rows 12 inches apart, Moneta, Calif. The beds, made partly when irrigation was first needed and partly later, are about 6 inches higher than the furrows and 3 feet apart from center to center. *C*, Field with plants set on the level in hills 18 inches apart and furrows only 3 or 4 inches below the beds, which are about 2 feet from center to center, Santa Clara Valley, Calif.

If the soil is of a type that permits the water to percolate so that the whole bed is moistened readily or if the subsoil is compact so that the water has time to penetrate laterally, wide beds may be used; if the soil is of a type through which the water percolates with difficulty the beds must be much narrower. They should be raised 2 to 12 inches above the furrows, according to the necessity for drainage.

In districts where surface irrigation is not practicable, sprinkler irrigation systems may be employed if water is available. Such systems are sometimes used in western Oregon and western Washington.



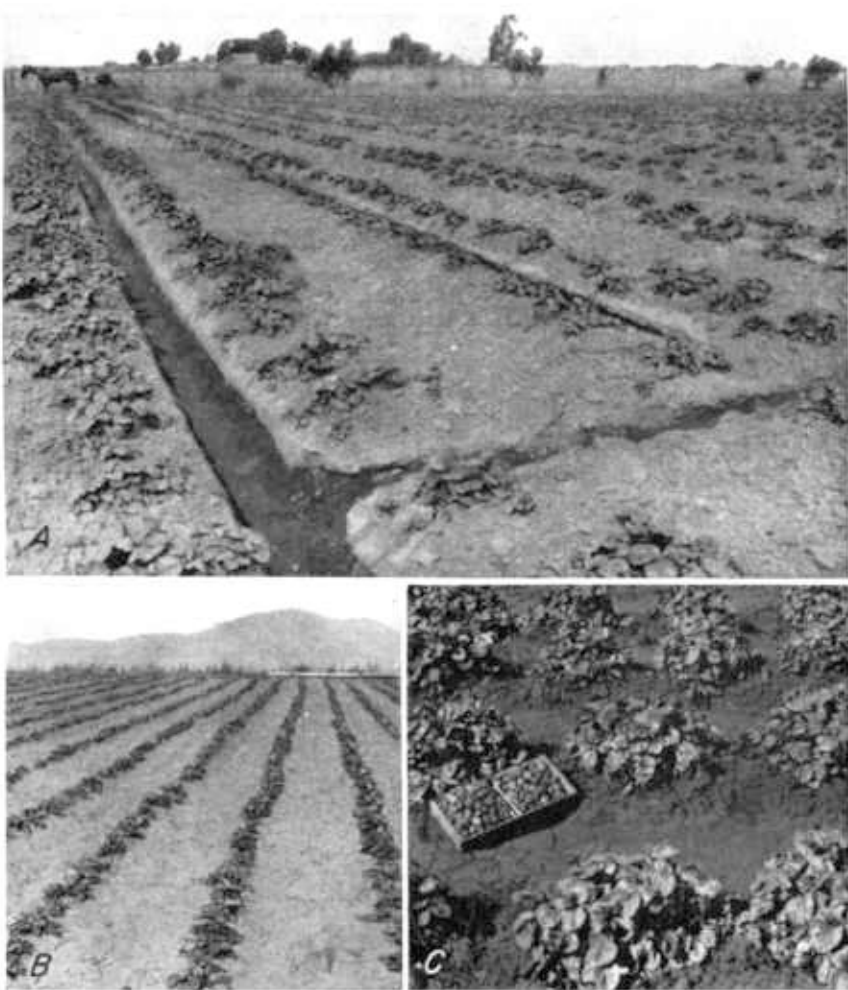


Figure 3.—*A*, Field of strawberries in which ditches 8 feet apart and 1 foot deep were made before the plants were set, Florin, Calif. The rows of plants on each side of the ditches are allowed to make a spaced-matted row. *B*, Field of strawberries planted 12 inches apart in rows 32 inches apart without furrows, Hood River, Oreg. *C*, Rows of strawberries 9 months after being set 12 inches apart in rows  $3\frac{1}{2}$  feet apart and with all runners removed as they appeared, Santa Rosa, Calif.

### VARIETIES FOR DIFFERENT STATES

Only a few varieties of strawberries are grown extensively throughout the entire semiarid region to which this bulletin applies. These varieties are listed in table 1.

In the western parts of North Dakota, South Dakota, Kansas, Nebraska, and Oklahoma very few strawberries are raised, but the Dunlap is perhaps as promising as any variety wherever conditions offer any promise of success. In western Texas the Klondike has been grown, but the Ranger is taking its place. In central California the Shasta and new California Agricultural Experiment Station selections are replacing the Marshall (Banner).

TABLE 1.—*Extensively grown strawberry varieties, arranged by States and sections*

[An asterisk (\*) before a name indicates that the variety is recommended for commercial planting. Varieties without an asterisk are grown more or less in the States and sections listed but are not considered so desirable for commercial plantings as the others]

State and section	Varieties	Remarks
Arizona:		
Throughout State---	{ *Missionary----- Klondike----- Arizona-----	
California:		
Los Angeles-----	{ *Klondike----- Blakemore----- Missionary-----	
San Francisco-----	{ *Shasta----- California Agricultural Ex- periment Station selec- tions.	
North of Fresno---	{ *Shasta----- California Agricultural Ex- periment Station selec- tions.	
South of Fresno---	{ *Klondike----- Blakemore----- Missionary-----	
Colorado:		
Throughout State---	{ *Dunlap----- *Howard 17 (Premier)---	Medium early. Early.
Idaho:		
Throughout State---	{ *Rockhill (Wazata)----- Howard 17 (Premier)---	Everbearer. Early.
Montana:		
Throughout State---	{ *Dunlap----- *Montana Progressive---	Everbearer.
Nevada:		
Throughout State---		Utah and California va- rieties should be tried.
New Mexico:		
Throughout State---		Colorado and Arizona va- rieties should be tried.
Oregon:		
	{ *Marshall (Oregon)----- *Corvallis-----	Frozen pack; local market. Canning, freezing; irri- gated valley soils.
Willamette Valley--	{ *Rockhill (Wazata)----- *Redheart----- *Narcissa-----	Everbearer. Canning, frozen pack. Very early; local market; irrigated sandy soils.
	Brightmore----- *Streamliner-----	Frozen pack, preserving.
Eastern part-----	{ *Marshall----- *Streamliner-----	Everbearer.
Utah:		
Throughout State---	{ *Marshall----- Brightmore----- Chesapeake----- Howard 17 (Premier)---	Freezing. Late. Early.
Washington:		
	{ *Marshall----- *Narcissa-----	Frozen pack, general use. Local market; sandy soil.
Western part-----	{ Redheart----- Brightmore----- President-----	Frozen pack, canning. Frozen pack, preserving. New.
	{ *Culver----- *Fairfax----- *Dorsett-----	
Eastern part-----	{ Howard 17 (Premier)----- Catskill----- Blakemore-----	

New varieties should be tested carefully before large acreages are planted to them.<sup>2</sup> Just as the varieties grown at present have supplanted those formerly grown because they are superior in some important characteristics, other varieties will probably be originated and in turn will supplant those now popular.

## **ESTABLISHING A STRAWBERRY PLANTATION**

### **OBTAINING THE PLANTS**

Whether plants for setting should be raised locally or procured from some other section depends in part on the diseases that might be present on the plants and in part on their need of a cool, dormant-season period. Growers in central California usually obtain their plants from their own nurseries; the southern California growers obtain their supplies from eastern growers. It is usually safer to get plants from nurseries located in areas with several weeks of cool weather, because strawberries need some dormant period in order to start the most vigorous growth.

Some States maintain an inspection and certification service whereby growers can produce plants that are certified to be reasonably free from disease. Certified plants usually give larger yields and live longer.

Strawberries are propagated chiefly by the use of runner plants. Where diseases are not serious and there is sufficient cool weather in winter to provide a rest period, each grower can easily raise his own stock from his bearing plantation. The vigorous younger plants along the sides of the matted rows can be used for this purpose. These plants develop and take root during the summer and fall and are more likely to start a vigorous growth after transplanting than the older plants that are ready to begin fruit bearing. In digging plants the roots of those left should be disturbed as little as possible.

### **TIME OF PLANTING**

In most sections the season of planting will depend on the period of greatest rainfall, although it is not necessary to rely so largely on rainfall where irrigation is used. As the period of rainfall is usually in the winter in California, Oregon, and Washington, growers in those States generally set their plants during the winter or spring, according to the conditions in the different areas. In most parts of California late fall and early winter are preferred, for if the plants are set in November or December and make good growth during the winter, considerable fruit can be harvested during the following summer. On sandy soils the plants can be set at almost any time during the winter, but on heavy soils they should be set just after the first rains. If the heavy rains occur before the planting is finished, however, the soil under most California conditions is in such poor condition for working that growers generally prefer to wait until early spring to set the remainder of the plants.

There is evidence that in California yellows of the Marshall (Banner) spreads from October to April and that if planting is done as late as May there is less of this disease than if the plants are set

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<sup>2</sup> Farmers' Bulletin 1043, Strawberry Varieties in the United States, which lists the varieties grown in all parts of the United States, will prove helpful to those interested in testing varieties.

in the period from December to April 15. Where planting can be done late, this fact should be considered.

In western Oregon and Washington and in northern irrigated areas early-fall or early-spring planting is preferred by most growers, for the cold is likely to injure late-fall-set plants that are not fully established. In southwestern Texas the plants are often set in early fall, and a crop is harvested the following spring.

#### PLANTING AND TRAINING SYSTEMS

Two general systems of planting and training strawberries are used—the hill system and the matted-row system in which the plants are spaced or not spaced.

When strawberry plants are to be grown under the hill system, they are commonly set 12 to 36 inches apart in the row and all runners are removed as they appear; or the plants are set 3 or 4 feet apart and the runner plants are allowed to root at definite intervals between the mother plants. Figures 2, *C*, and 3, *B* and *C*, show fields trained to this system, which is widely used throughout the irrigated areas of the United States as well as in the South Atlantic and Gulf Coast States and with overhead irrigation in the Northwestern States.

Under the matted-row system, plants are set 18 inches to 4 feet apart in rows, and part or all of the runners that appear are allowed to root. Perhaps the most common practice in irrigated areas is to allow each plant to make a definite number of new runner plants. These plants are spaced 6 to 12 inches apart, and all others are removed as fast as they develop. Spacing is done by covering the tips of the runners with earth as soon as they begin to enlarge or by setting young runner plants. Figures 2, *A*, 4, *A*, and 12 (p. 19) show fields of strawberries grown under this system.

Both the hill and the spaced-matted-row system are used extensively in irrigated areas. The most suitable system will depend on local conditions. Where the soil is heavy and rather impervious to water, narrow beds must be made and the hill system should be adopted. Where the soil is penetrated readily and for some distance by irrigation water, the beds may be wider and the spaced-matted-row system may be used. One advantage of the matted row is that the beds are wider and there are fewer furrows to care for. Both systems, however, depend on intensive cultivation for the best results; if sufficient labor is available, one or the other should be used. Where labor is not abundant and it is not desirable to use the most intensive methods, a matted row in which the plants are not spaced may be used. This system, however, is rarely adopted in irrigated areas.

In the Los Angeles section of California, where the double-row hill system is used, the plants are set at intervals of 4 feet in rows 3 to 3½ feet apart. Runner plants are so spaced that two rows about 12 inches apart, with plants at intervals of 6 to 12 inches, finally occupy each bed, as shown in figures 2, *B*, and 4, *B*. This system is used in many districts and is one of the best wherever conditions permit its adoption.

In the counties just south of San Francisco the plants may be set in accordance with the hill system, 18 inches apart in rows 2 feet apart, as shown in figure 2, *C*, or 1 foot apart in rows 3½ feet apart, as shown in figure 3, *C*. However, the double-row system is common; under it the rows are 12 to 14 inches apart with an alley about



Figure 4.—*A*, Strawberries growing in spaced-matted rows on raised beds, Watsonville, Calif.; *B*, strawberries growing under hill system in double rows (plants 8 inches apart, rows 14 inches apart, and furrows between beds 28 inches wide), Santa Clara, Calif.

28 inches wide between the beds, as shown in figure 4, *B*. The spaced-matted-row system, as shown in figures 2, *A*, and 4, *A*, is probably the one most generally used in this section. The beds are 2 to 3 feet wide and the furrows 1 to 2 feet wide. When this system is used the usual custom is to set two rows of plants on each bed next to the edges. The runner plants are then spaced 6 to 8 inches apart as they develop.

In the Sacramento section of California the spaced-matted-row system is commonly used. The beds are made 6 to 9 feet from center to center. The plants are set about 18 inches apart along both edges

of the furrows (fig. 4, *A*), and a spaced-matted row along each side is formed from the runner plants (figs. 2, *A*, and 12, p. 19).

In parts of the Willamette Valley and of western Washington the hill system is used, the plants being set in rows 3 to 3½ feet apart and 18 inches to 3 feet apart in the row. When they are set 3 by 3 feet cross-cultivation is used. In some districts, where summer moisture permits, a matted row of plants spaced about 8 to 12 inches apart is used to give larger yields. Narrow matted rows are largely used in eastern Oregon and Washington.

#### PLANTS NEEDED PER ACRE

When strawberry plants are spaced according to the planting systems commonly used, the number needed per acre is as follows:

Distance apart:	Plants per acre (number)	Distance apart:	Plants per acre (number)
2 feet by 1 foot-----	21, 780	2½ feet by 1½ feet-----	11, 616
2 feet by 1½ feet-----	14, 520	3 feet by 2 feet-----	7, 260
3 feet by 1 foot-----	14, 520	3 feet by 3 feet-----	4, 840
3½ feet by 1 foot-----	12, 446	3 feet by 4 feet-----	3, 630

If there is little danger of losing plants from any cause, only the number indicated will be needed. If there is danger of loss, a somewhat larger number should be obtained in order to insure a full stand, as the expense of irrigating and caring for a field that has many blank spaces will be out of proportion to the value of the crop obtained.

#### CARE OF PLANTS BEFORE SETTING

When the plants are received from a nursery they are usually tied in bundles, as shown in figure 5, *A*, or packed in apple or orange boxes. Good plants usually have bright, light-colored root systems. When grown on very dark soil, however, the roots may be brown or yellowish. If the plants are at all dry upon arrival, the roots should be soaked in water for a few hours before planting or heeling in. If the plants cannot be set at once, the bundles should be opened and the plants separated and heeled in, as shown in figure 5, *B*. The soil packed about the roots of the plants should be thoroughly moistened.

Strawberry plants that are dug for planting after spring growth has begun are checked in their subsequent growth. Late-spring rains often prevent early planting, especially in Oregon and Washington. Therefore, before March 15, large growers often dig plants which are still dormant and hold them in cold storage until planting conditions are favorable. Plants well packed so that they do not dry out and then held in cold storage at temperatures of 31° to 38° F. make better growth than plants dug late and planted immediately.

The plants to be set should be protected from the sun and from drying winds while they are being distributed in the field, either by means of burlap or old sacks or in some other effective way. An old fertilizer sack may be used for protecting the plants while they are being dropped (fig. 6, *B*).

#### SETTING THE PLANTS

When furrows and beds are made in preparing the soil, they will show approximately the rows on which the plants are to be set. Care should be taken, however, to make the rows straight. The exact place for each individual plant may be indicated by a row marker similar to that shown in figure 7, *A*.

If the soil is very mellow, a place for the roots may be made with the hand; but in heavier soil a dibble or trowel (fig. 7, *B*) or the tools known as punch and tongs (fig. 6, *A*) may be used. A hole is made with the punch, and the plant is picked up with the tongs and placed

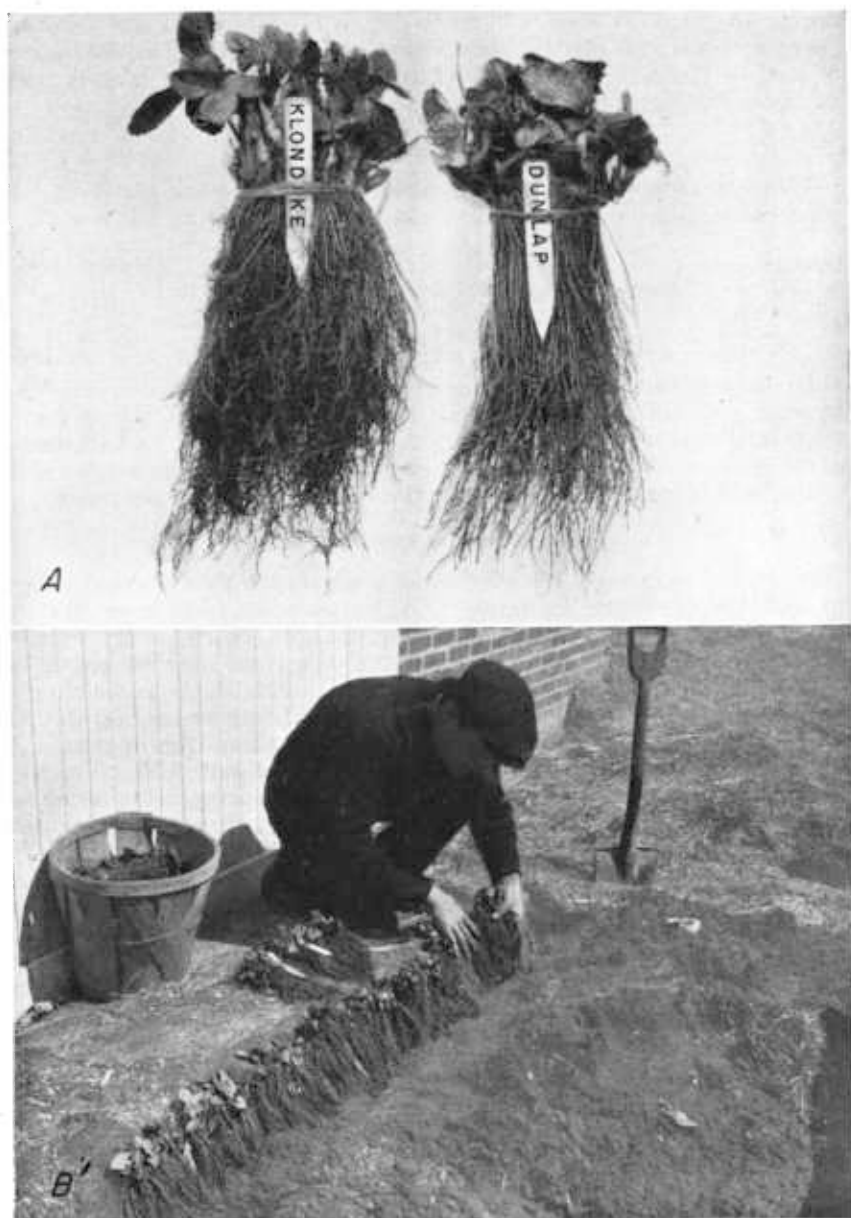


Figure 5.—*A*, Bundles of plants of the Klondike and Dunlap strawberries. The Dunlap plants are not so large as those of the Klondike. *B*, Heeling in plants until it is convenient to set them in the field. The bundles are opened, each plant is laid by itself with the crown even with the surface of the ground, and moist soil is packed firmly against the roots.



Figure 6.—*A*, Punch and tongs commonly used for setting sweetpotato plants and suitable for setting strawberry plants, especially in mellow soil. *B*, Fertilizer sack used to protect strawberry plants from sun and wind while they are being dropped; a hole is cut for the dropper's head, a slit is made across one side, and plants are placed in the bottom of the sack.

in the hole. Planters accustomed to use of the tools can set 10,000 plants in 8 hours, and experts can set a much larger number. Plant-setting machines are also used in this region, and their work is thought by some growers to be superior to setting by hand.

Perhaps the most important points in setting plants are to place them at the right depth and to firm the soil thoroughly about the roots after they are set. If the plants are set too high or the soil is not sufficiently firm they will dry out and die, whereas if they are set too low and the crown is covered with soil they may rot. Figure 8 shows plants set too shallow, too deep, and at the proper depth.

## CARE OF PLANTS AFTER SETTING

### REMOVING UNWANTED FLOWER STEMS AND RUNNERS

If the plants are set in early spring, flower stems frequently appear in a short time. Unless the plants are thoroughly established in the



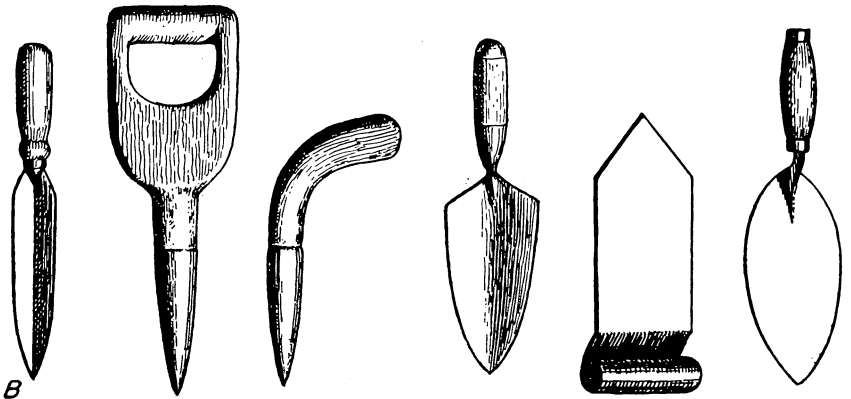
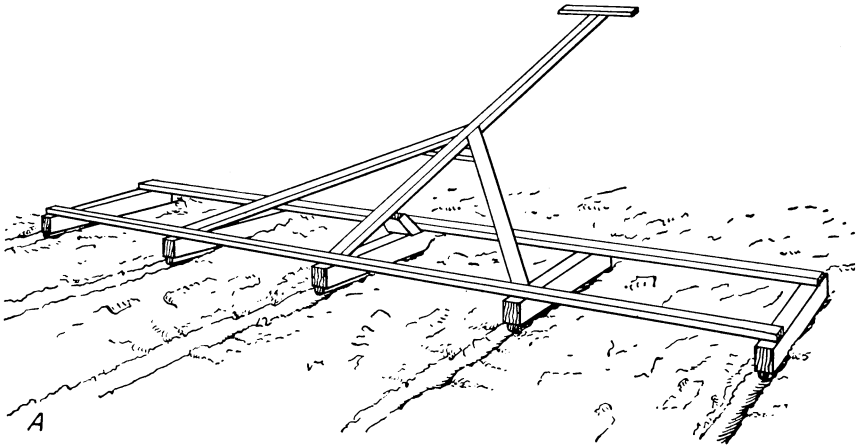


Figure 7.—*A*, Home-made, hand-operated marker for indicating where the rows of plants are to run. *B*, Trowels and dibbles of the types used in setting strawberry plants. The implement next to the right end is considered the best under most conditions.

soil these stems should be removed, as fruit production is too great a strain on plants not fully established. When a large number of runner plants are needed, the flower stems should also be removed, as this will increase the number of runner plants that are made.

When all the runners that develop are allowed to root without any restrictions, too many plants form in the matted rows and some means should be taken to thin them. Plants in matted rows should be at least 6 to 10 inches apart; when necessary, they should be thinned with a hoe or by hand in order to prevent overcrowding.

When the plants in the matted row are spaced, the strongest runners are selected. As soon as the tip of a runner has enlarged and a leaf appears, it is covered with soil. Each runner is thus made to take root at a predetermined distance from the parent plant and from adjoining runner plants. Sometimes a large number of runner plants are made to root, either in distinct rows, as shown in figure 2, *B*, or at a distance of 7 or 8 inches from each other (figs. 2, *A*, 3, *A*, and 12, p. 19). If the runner tips cannot be properly spaced, they may be left until well-rooted and then reset in the proper space. All runners

except those to be used are removed with a hoe, knife, or runner cutter or in some other way.

The production of runners and the development of runner plants constitute a severe drain on the mother plant. Therefore, when strawberries are grown in hills, the frequent removal of runners is important. Runners will need to be removed more frequently the first year than in later years and from some varieties more frequently than from others. In Oregon and Washington runners need to be cut 5 to 7 times the first year on the Marshall and 6 to 10 times the first year on some other varieties; in the second and following years 2 fewer cuttings probably will be sufficient.

Tests have shown that under some conditions plants with runners removed every 2 weeks produced 75 percent more fruit than those with runners removed every 6 weeks. Under many conditions frequent removal is even more important than indicated by these tests. In still other tests plants were allowed to make runners after September 1.



Figure 8.—Strawberry plants set (A) too deep, (B) at proper depth, and (C) too shallow.

An average of only 4.5 runner plants per mother plant was produced after that date, but the yield of the mother plants was reduced to less than half that of adjacent plants on which no runners were left.

Runners may be removed with rolling disks attached to both sides of a cultivator or with runner-cutting tools. Figure 9 shows a circular cutter made from the blade of an old saw, and figure 10 shows a cutter made somewhat like a sickle, which is used extensively where berries are grown on raised beds. Where the rolling disks will do good work, they should be used. The other tools are effective under some conditions but involve hand labor.

#### TILLAGE

Tillage is practiced primarily to keep down weeds. It should begin soon after the plants are set and continue during the growing season. As soon as possible after each irrigation the irrigation furrows should

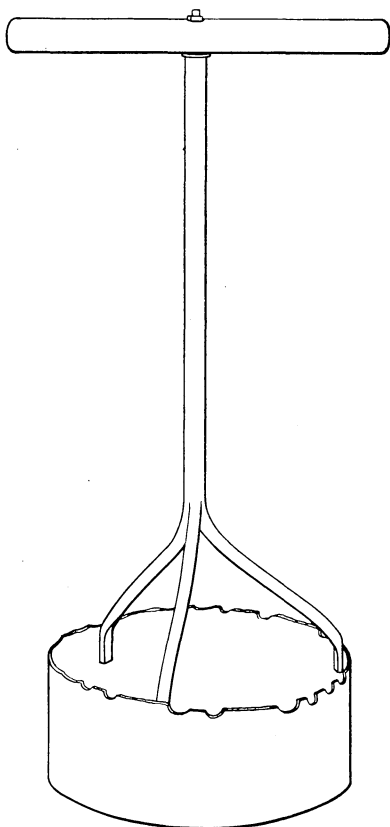


Figure 9.—A strawberry-runner cutter used to supplement the rolling disk on the cultivator or under some conditions instead of the disk. The blade of this cutter was made from an old crosscut saw. The lightest weight saw blades should be used.

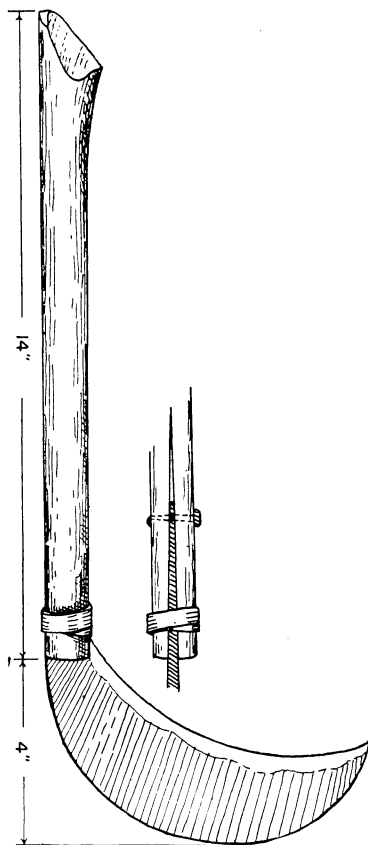


Figure 10.—A sicklelike cutter much used in California to cut runners and to trim off old leaves.

be cultivated. This leaves the surface of the soil loose, and thus helps keep the soil in good condition. Where furrows are not cultivated, the soil may become waterlogged and on drying shrink so that large cracks appear. Such cracks not only increase the loss of water by evaporation but may even break the roots of the plants. Various attachments for tractors are now available and in general use. Growers should use the tractor attachments which best stir the soil and control weeds but which do not go deep enough to destroy the feeding roots.

### MAINTAINING SOIL FERTILITY

The use of stable manure and fertilizers on strawberry fields is governed largely by the same principles that apply to other crops. As soils differ greatly in their composition, the use of fertilizer is usually determined by each grower for his own conditions. Fertilizer requirements can be determined by applying the different plant foods,

nitrogen, phosphoric acid, and potash, both separately and in various combinations and in different quantities, to small plots of strawberries on which records of yields are kept. In like manner the effect of different quantities of stable manure can be tested on small plots. In general, the fertility of the soil can be established best before a plantation is made.

A good crop of berries removes considerable quantities of nitrogen, phosphoric acid, and potash. Most western soils, except coarse sand, were at one time well supplied with these plant foods so that large crops could be produced without fertilizers, provided the physical condition of the soil was good. Therefore, if the soil had been kept in a satisfactory condition by the addition of humus and by adequate irrigation and tillage, many soils needed no commercial fertilizer or stable manure. In most districts, however, growers have found in recent years that the use of fertilizer is profitable, but the applications that can be made with the greatest gain differ with different soils and soil conditions. Much can be done to insure productive plantations by seeing to it that the soil is in the best possible state of fertility before the strawberry plants are set out.

When nitrogen is to be used it should be in the form of sulfate of ammonia if the soil is alkaline, neutral, or only slightly acid and in the form of nitrate of soda if the soil is very acid.

### IRRIGATION

In all the region to which this bulletin applies, except a very small area in northwestern California and the area of Oregon and Washington west of the Cascade Mountains, irrigation is necessary in strawberry production. Experiments have shown that in the areas where irrigation is not absolutely necessary it may be profitable. At the Oregon Agricultural Experiment Station irrigation doubled the average net income from fields of the Marshall variety but not from fields of the Ettersburg 121. At least a part of the increased production of the Marshall resulted from the larger plants in irrigated fields early in September, when fruit-bud development for the following spring begins. Fruit buds in the Ettersburg 121 do not begin to develop until nearly November and after fall rains have caused a vigorous growth; therefore irrigation does not seem to be so essential with this variety. As most varieties grow like the Marshall, irrigation may be expected to give similar results.

Strawberries must have an ample supply of moisture, not only when they are bearing fruit but also throughout the growing season. As the root system is shallow, the surface soil must be kept moist and the irrigations must be more frequent than those required by many plants whose roots penetrate the soil deeply. The number of irrigations, however, will depend largely on the character and frequency of the tillage used in conserving moisture and on the type and condition of the soil. If the furrows are thoroughly cultivated as soon as moisture conditions permit after each irrigation, the number of applications of water is materially smaller than the number required when cultivation is neglected. In the lighter soils during the bearing season the fields may be irrigated as often as every 4 to 6 days, and in heavy soils every week or two. During the months when the plants are not fruiting, irrigation need not be so frequent as when the crop is developing, only enough water to keep them in a thrifty growing condition being neces-

sary. This may mean irrigating as often as once each week or only four or five times during the season. Growers consider it essential to irrigate as few times as possible the first year in order to establish a deep root system.

During the fruiting period the usual practice is to irrigate immediately after each picking. Sometimes, when there is danger that the water in the furrows may not be absorbed before the next picking, the field may be covered by two applications, alternate furrows being irrigated in turn. The pickers can then follow the unirrigated furrows.

In California, especially in the Santa Clara Valley, the plants of some varieties produce fruit for several months, from late in March or early in April until September or October and sometimes even until December. In that State, therefore, water will be needed for bearing plantations through a much longer season than in States where only an early-summer crop is produced. In western Oregon and Washington sprinkler irrigation systems are being profitably used where only one to three applications of water are made during the summer to keep plants growing vigorously. These systems are in use on land that cannot be irrigated easily by surface methods.

### STRAWBERRIES AS AN INTERCROP

Strawberries are very often grown as an intercrop in orchards and vineyards in most irrigated areas. Where the water supply is under control of the grower and a sufficient quantity can be used to supply the trees and vines that are being grown for the permanent crop and the strawberries as well, this plan is practicable. If properly managed, the strawberries should pay a large part of the expense for the care of the permanent crop until it comes into bearing. Figures 4, B, and 11 show strawberries as an intercrop in prune and apple orchards. In a



Figure 11.—Marshall strawberries interplanted in a young orchard in western Oregon.



*Figure 12.*—Strawberries interplanted in a vineyard according to the spaced-matted-row system.

few locations strawberries are used as an intercrop in cherry and pear orchards and to a slight extent in orchards of other fruits. They are also frequently used in vineyards, as shown in figure 12. The strawberries, which are planted at the same time as the grapevines, are left until they become unproductive or the permanent planting needs the entire space. Usually four crops of strawberries are obtained before the plants are plowed up.

In nonirrigated areas the interplanting of orchards with strawberries is inadvisable except under well-considered restrictions.

### **DURATION OF A PLANTATION**

The length of time during which a strawberry plantation is maintained depends chiefly upon its productiveness. If the humus content is ample so that the soil is in good tilth and if diseases and insects are not troublesome, the plantation may produce fruit for several years. In California the crop is usually largest the second year. Large crops may also be obtained in some areas in the third and fourth years, after which the plantations are usually continued for three or four seasons.

### **RENEWING A PLANTATION**

#### **REMOVING TOPS AND OLD LEAVES**

Frequently in Oregon and Washington the tops of the plants are cut off at the surface of the ground as soon as the crop has been harvested. This practice aids in controlling the strawberry crown moth and leaf diseases. Removing the tops as soon as the crop is harvested may benefit future growth, but injury may result if removing the tops

is delayed. Scythes, sickles, or hoes are used for cutting the tops. The new growth starts out quickly, and the later care of such fields involves less labor than otherwise would be necessary. Figure 13 shows a field in which the foliage on some of the plants has been cut.

It is common in California to clean off all old and dead leaves, usually in December and January. This is done as a sanitary practice to help in the control of aphids (plant lice) and red spider mites and of fungi on rotting leaves that would rot the fruit in wet weather. Though this process is laborious and expensive, growers generally consider it worth while, both to control pests and to make the crop earlier and the berries larger. Some consider it better to pull off the old leaves rather than trim them, leaving the old leaf stems on the plant. Hand cutters similar to that shown in figure 10 are used for trimming.



Figure 13.—A strawberry field soon after harvest, Vashon, Wash. The tops of the plants at the right have been cut.

#### THINNING THE PLANTS

In the few places in the West where the matted-row system is used, the plants are generally thinned immediately after the foliage has been cut. In some cases the rows are narrowed by plowing up a part of each side, and the remaining plants are thinned with a hoe. In other cases two-thirds of the width of each row may be plowed up, including the plants that have recently produced a crop. Later in the season runner plants that develop are allowed to replace those removed. Thus the plants that have been weakened by fruit production are replaced by new and vigorous plants for the next season's crop.

In many of the sections of this region it has been found profitable to apply commercial fertilizers at this time. If the planting is irrigated, fertilizers may be applied immediately after harvest. In nonirrigated plantings fertilizers may be applied just before fall rains begin.

## HARVESTING AND SHIPPING

The harvesting season varies greatly in the various parts of the irrigated areas, being affected both by the climate and by the variety. In southern California the Klondike produces a heavy crop during March, April, May, and June, but it yields little or nothing thereafter until the next season. The principal varieties grown in central California usually produce continuously from April to June and to a less extent until October or November. Most of the berries ripening in the summer and fall are shipped to local markets and to the East. In Oregon most varieties produce fruit only during the early-summer months.

The main shipping season in most other sections is during the early summer only. In the Steamboat Springs district of Colorado the season is during July and August.

In Oregon and Washington 24-cup, or box, crates are used, and in California 12-cup crates are employed for shipping and 30-cup crates for local markets. The cups used for strawberries contain approximately 12 ounces of berries. Figure 14 shows one type of carrier used in picking. Another type of carrier, used by pickers in southern California, is shown in the cover illustration.

## COLD STORAGE <sup>3</sup>

Fresh strawberries can be stored commercially only for very short periods. Ten days is the usual maximum storage period even when the berries are held at a temperature of 32° F. After about 10 days, sometimes sooner, the fruit loses its fresh bright color, tends to shrivel, and deteriorates in flavor. At temperatures of 40° or above, loss from decay caused by fungi may become serious. Gray mold rot, rhizopus rot, and leather rot are the most common storage diseases of strawberries.

## UTILIZATION

Strawberry products worth many million dollars are manufactured each year. Among the more important are preserves, jams, conserves, essences for flavoring candies and for use as flavoring extracts, sirup for soda fountains, and crushed fruit for flavoring ice cream and sauces. Large quantities of strawberries are also canned. The varieties best suited for preserving are firm and light red and have yellow seeds. Acid, firm-fleshed sorts, deep red to the center and with a strong strawberry flavor, are best for canning; among the best varieties for canning are the Corvallis, Redheart, and Ettersburg 121. The Marshall is used mostly in the frozen pack and for the preserving and ice-cream trade. Brightmore, an especially promising new variety, was selected and named because of its high qualities in the frozen pack and for preserving.

Many frozen-pack plants have been erected in the larger producing areas. Most of the preserving factories are located in the eastern cities, and the fruit is shipped to them. Strawberries are in the best condition for use if picked when very firm, even before they are fully ripe, and barreled with sugar as soon as possible. In utilizing straw-

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<sup>3</sup> Prepared by D. F. Fisher, principal horticulturist, Division of Fruit and Vegetable Crops and Diseases.





*Figure 14.*—Strawberry picker with a carrier, Corvallis, Oreg.

berries in the home or for the market the experience of these concerns in selecting suitable varieties and using firm berries should be followed.

The frozen-pack method is used to preserve about 85 percent of the berries grown in Oregon and Washington.<sup>4</sup> Frozen-pack berries are largely used for fruit sirups and crushed fruit required by the soda-fountain, ice-cream, baking, and confectionery trades and for making jams, preserves, and jellies. An increasing retail trade in frozen berries for dessert purposes is also developing. At present about 60 percent of the frozen berries are packed in barrels, kegs, 30-pound cans, and other large containers for the larger users. One-pound paraffin-paper containers of berries are generally used for the retail trade; these berries constitute about 40 percent of the entire frozen pack.

Most of the barrels or kegs used are coated with paraffin on the inside to prevent the berries from absorbing a woody taste. Some of them, however, are made of woods that require further treatment to prevent the berries from absorbing the taste of the wood. Enameled cans are used to avoid corrosion. All containers must be made as nearly airtight as possible to preserve the color and flavor of the fruit. The barrels hold 450 pounds of berries and sugar when 2 parts of berries to 1 part of sugar are used.

The berries for the frozen pack are usually picked without the hull, sorted, and washed in various types of washing machines. Usually there is a water tank into which the berries are dumped for a brief period to loosen the dirt. They are removed from this tank by an endless conveyor belt that carries them under sprays of fresh water, and they are then delivered to inspection belts where they are allowed to drain and where the final sorting and grading are done. The berries are then run into barrels or other packages together with the desired quantity of sugar.

Although it may be desirable to vary the proportion of fruit to sugar with different varieties of berries, depending on the particular use to be made of the fruit, the usual commercial proportion is 3 or 4 pounds of berries to 1 pound of sugar. In packing the larger containers the berries and sugar are added in alternate layers to insure more thorough mixing. While the container is being filled, it is usually jolted, either mechanically or by hand, to insure each berry being coated with sugar. After being filled, the barrels are headed and smaller containers are tightly lidded. They are then transferred to a freezing room as soon as possible. A temperature of 0° F. or below in the freezing room is desirable for barrels and large containers to quickly reduce the temperature of the large mass of warm fruit, to prevent fermentation and spoilage, and to freeze the fruit in the center of the barrel as quickly as possible. In the small-sized containers, especially the 1-pound "consumer packages," satisfactory frozen products can be obtained by using a temperature of 0° to 10° for both freezing and storage.

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<sup>4</sup> See U. S. Dept. Agr. Tech. Bul. 148, *The Frozen-Pack Method of Preserving Berries in the Pacific Northwest*. Out of print, but may be consulted in libraries.

## DISEASES <sup>5</sup>

Yellows is a virus disease known from western Washington to southern California and affects all varieties, but the Marshall (Banner) variety most severely. It is most serious in the Santa Clara and Watsonville districts, where losses have been so great that many growers have given up the Marshall. The disease is carried by aphids (plant lice) from plant to plant, especially during the months from October to April. The diseased plants never recover, and all runner plants from them have the disease, are dwarfed, and produce little or no fruit (fig. 15). Using clean planting stocks, setting them as late as May 1, spraying to control aphids, isolating fields from infested plantings, and roguing diseased plants help to control yellows.

Crinkle is another virus disease found in Washington, Oregon, and California. This disease is also spread by aphids and causes plants to become dwarfed and produce little fruit. No control is known except planting disease-free stock. Such stocks of plants may be built up by careful inspection and by roguing all diseased plants.

Verticillium wilt and red stele root disease are two known root diseases that injure or kill the plants. Red stele root disease attacks the young roots in the cool, wet weather of winter and may finally kill the plants. It is most important in western Oregon and Washington on the heavier soil types. Because the roots are destroyed, as soon as warm dry weather occurs the plants wilt. The disease is recognized by the dark-red centers of the affected roots. The Marshall is slightly resistant. Verticillium wilt attacks the crown, causing characteristic wilting and dying of the entire plant. The older leaves usually die first. This disease is known to be serious in central California, where as many as 75 percent of the plants may be killed outright the first year. It is most active in cool weather. Tomatoes are among the crops affected most, and strawberries are often severely attacked when planted after this crop. Potatoes and raspberries are among the other common crops severely attacked. For both verticillium wilt and for red stele root disease control measures consist in proper rotation and in the setting of clean plants.

Summer dwarf, caused by a nematode that lives in the crowns of the plants, is frequently found in fields of the Klondike and other varieties in southern California. This disease dwarfs the plants, and the leaves are distorted and small. Its control consists in setting clean plants; if affected plants are found they should be taken out of the field.

## INSECTS

The strawberry root weevil (*Brachyrhinus ovatus* (L.)) is a serious pest in British Columbia, Washington, and southward into the Willamette Valley of Oregon as far as Salem. Satisfactory methods for controlling this pest with poisoned baits have been worked out.

The cyclamen, or strawberry, mite (*Tarsonemus pallidus* Banks), widely distributed throughout the northern part of the United States and Canada, has been found causing serious injury to the Mastodon

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<sup>5</sup> Farmers' Bulletin 1891, Diseases of Strawberries, gives more complete information on this subject.

everbearing in Oregon and to the Nick Ohmer and occasionally the Marshall in the Santa Clara and Watsonville districts of California. It has also caused some injury to the Missionary and Klondike varieties near Los Angeles. Plants attacked by this mite are dwarfed, and in severe cases the entire crop is lost. Because it is difficult to rogue



Figure 15.—A, Plants of Marshall strawberry dwarfed by yellows, Santa Clara, Calif.; B, plants of a resistant sort.

all mite-infested plants and no effective spray has been found, control of this pest lies in setting clean plants. Large quantities of planting stocks are now being cleaned of cyclamen mites by immersing them in hot water or treating them with the so-called vapor heat. New plantings should be made some distances from older infested fields.

The meadow spittlebug (*Philaenus leucophthalmus* (L.)) is especially serious in Oregon and Washington but can be controlled by dusting with rotenone-containing dusts. Cutting off the tops aids in the control of the strawberry crown moth (*Ramosia bibionipennis* (Bdvl.)), and planting young plants usually keeps this pest under control. No satisfactory control has been found for the omnivorous leaf tier (*Cnephasia longana* (Haw.)). This worm is most serious on the early berries. White grubs, the larvae of May beetles, or June bugs, may be serious on former sod land and on some sandy soils.

Growers should write to their State agricultural colleges or to the Bureau of Entomology and Plant Quarantine, United States Department of Agriculture, Washington 25, D. C., for information on control methods for strawberry insects.